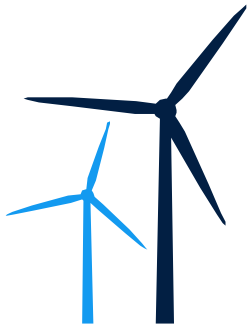


# EXPLORING AFRICA'S UNTAPPED WIND POTENTIAL

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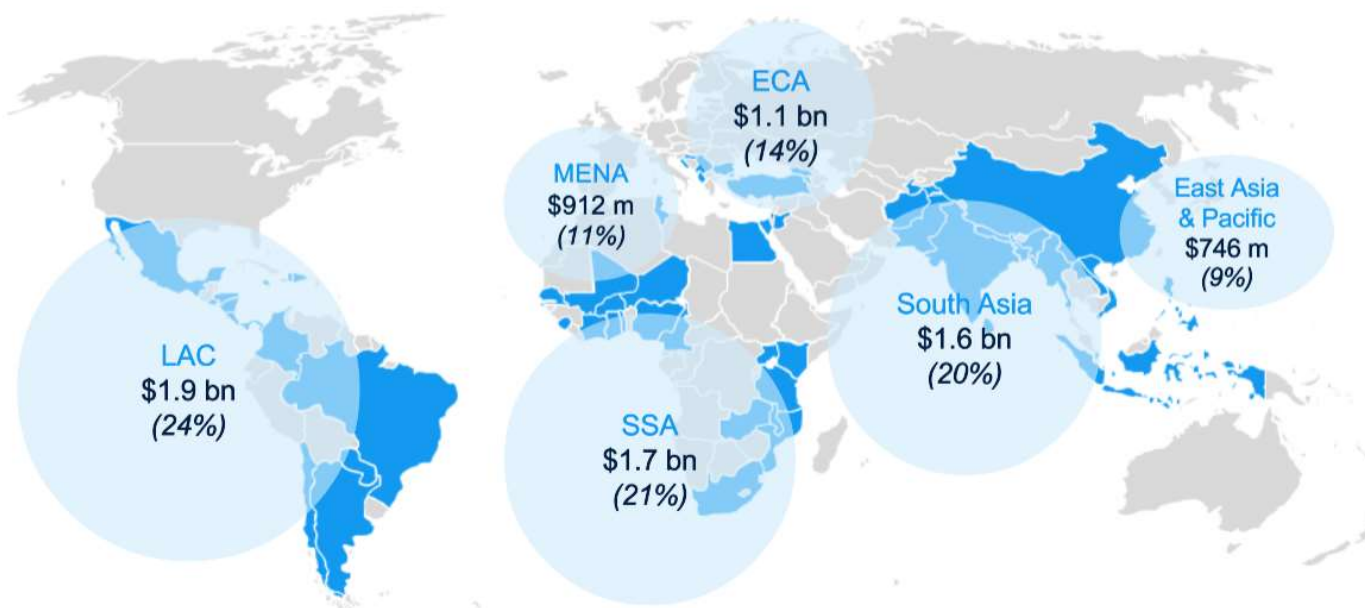


**Sean Whittaker**  
**Principal Industry Specialist, IFC**

**October 5, 2020**

# IFC's Energy Portfolio

\$8 billion energy portfolio (June 2020)



# IFC's Wind Portfolio

From 2009 to 2019

38 projects in 19 countries

\$1.6 billion own account

3.9 GW total capacity

Europe and Central Asia

Kavarna (Bulgaria)  
Cernavoda, Pestera (Romania)  
Sibenik, Jelinak, Rudine  
(Croatia)  
Rotor Elektrik (Turkey)  
Alibunar, Dolovo (Serbia)

Middle East & North Africa

Daehan, Xenel, Tafila (Jordan)

Latin America &  
Caribbean

Norvind (Chile)  
EVM, Eurus (Mexico)  
Enel (Brazil)  
BMR (Jamaica)  
Penonome (Panama)  
Pecasa (Dominican Rep)  
Achiras, La Castellana  
(Argentina)

Sub Saharan Africa

Amakhala (South Africa)

East Asia & the Pacific

Guazhou (China)  
Techno, NSL, Bhilwara, LNJ,  
Inox, DJ Energy & Uttar Urja,  
Green Infra, Ostro (India)  
Senok (Sri Lanka)  
Zorlu, Metro, Gul Ahmed, TGL,  
TriconBoston (Pakistan)

# So, does Africa have a Good Wind Resource?

## Engaged Everoze & Vortex to answer this question:

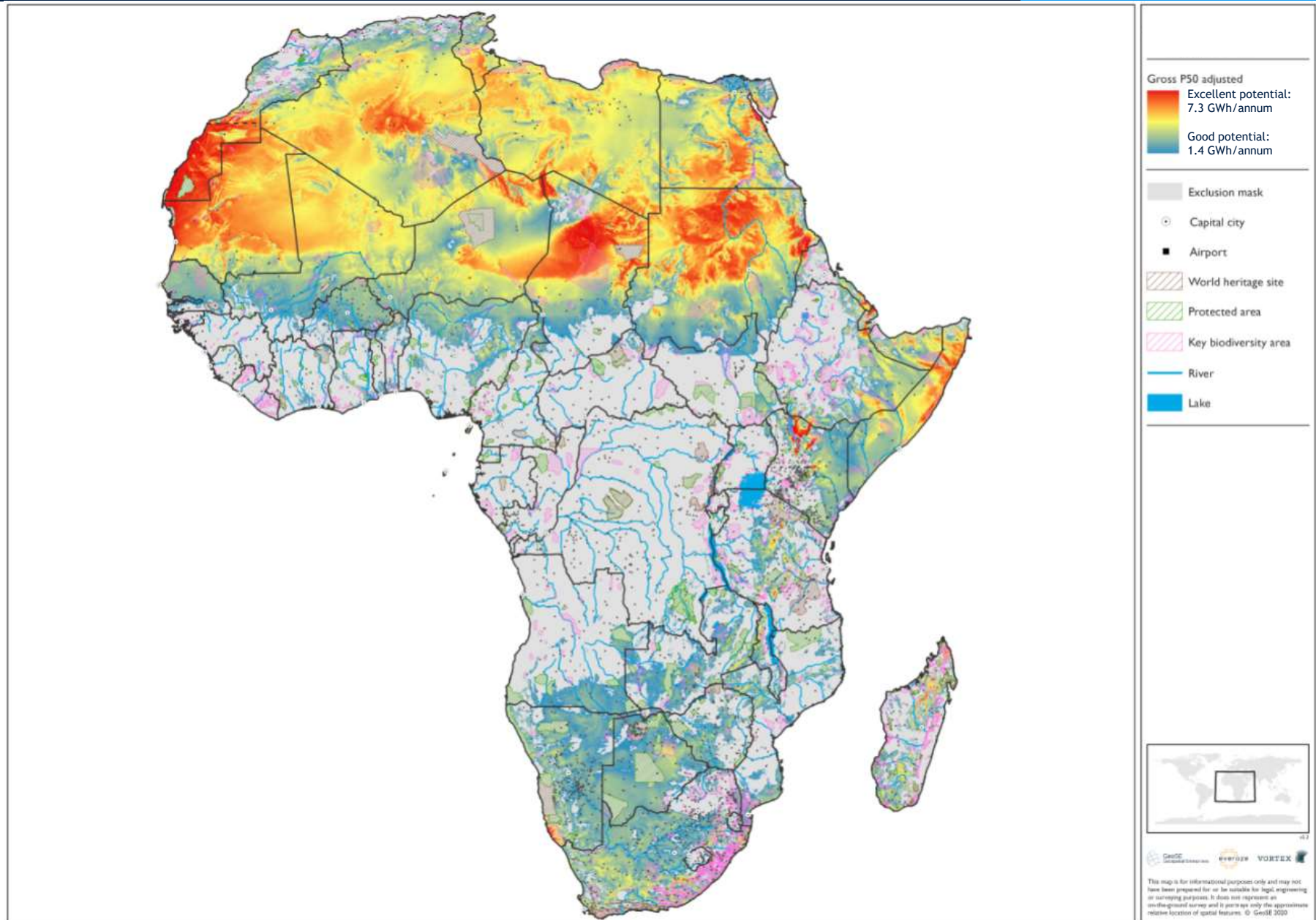
1. Assessment of technical potential for entire continent using basic constraints
2. Identify short-list of countries for detailed assessment
3. Detailed analysis of target countries using deeper constraints

## Everoze assumptions:

- Use high resolution wind data:
  - Global Wind Atlas: 250m x 250m resolution
- Modern turbines matched to site conditions:
  - Hub height = 125 meters
  - Rotors = 120 to 158 meter diameter
  - Rated power = 4.3 to 5.3 MW
- Apply basic constraints for technical and E&S:
  - Wind speed, elevation, slope, urban areas
  - High population density, protected areas
- More detailed constraints will come later

Constraints	Exclusions
Wind resource quality	Exclude if wind speed < 6.0m/s at 150m Exclude if wind speed > 16.0m/s at 150m
Elevation	Exclude if elevation > 2,000m
Slopes	Exclude if slopes > 20%
Land use cover	Exclude urban areas and airports (2km)
Population density	Exclude if population density > 200 people/km <sup>2</sup>
Water bodies	Exclude
Protected areas	Exclude if UNESCO World Heritage site Exclude if IUCN Protected Area Management codes Ia, Ib and II.

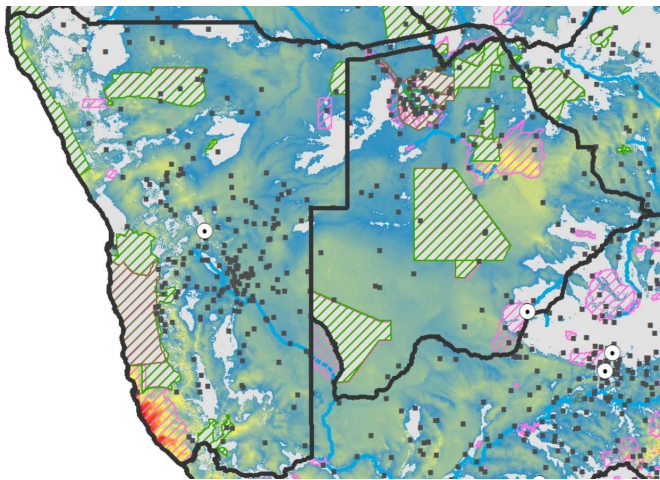
# Technical Potential – All locations meeting criteria



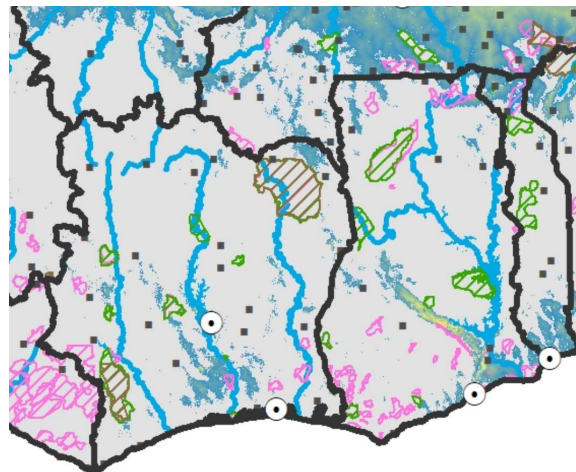


# Technical Potential – All locations meeting criteria

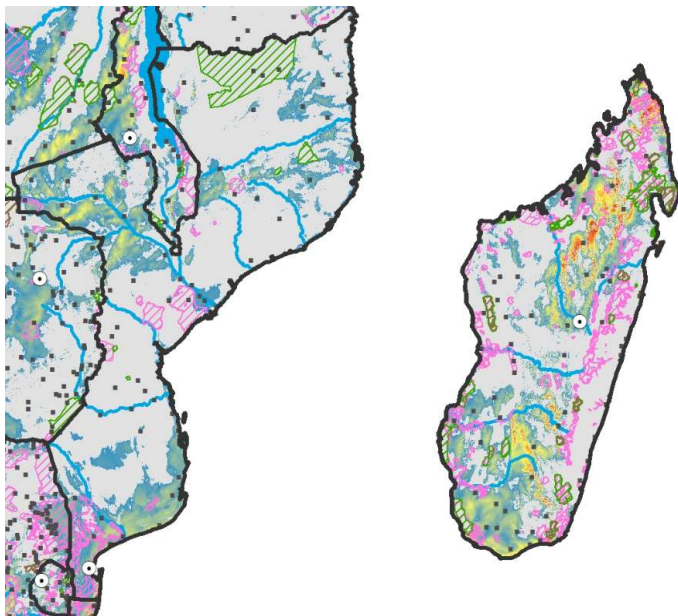
Namibia, Botswana



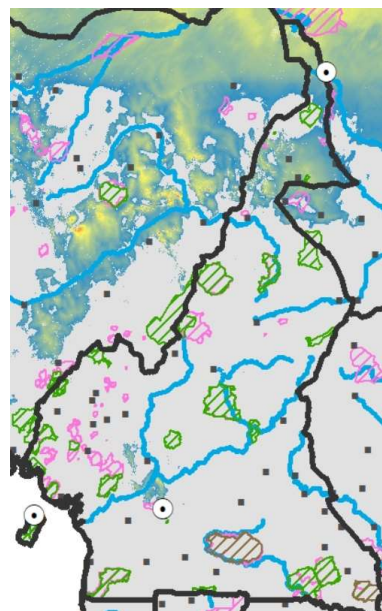
Cote d'Ivoire, Ghana, Togo



Mozambique, Madagascar



Cameroon



Gross P50 adjusted  
Excellent potential:  
7.3 GWh/annum  
Good potential:  
1.4 GWh/annum

Exclusion mask  
Capital city  
Airport  
World heritage site  
Protected area  
Key biodiversity area  
River  
Lake



GeoSE  
GeoSE  
VORTEX  
This map is for informational purposes only and may not have been prepared for or be suitable for legal, engineering or surveying purposes. It does not represent an on-the-ground survey and is points only the approximate relative location of spatial features. © GeoSE 2009

# Total potential = 180,000 TWh/year = 250x continental demand

Country	Potential net energy generation [TWh/annum]	Potential installed capacity [GW]	Average capacity factor [%]	Exclusion <sup>1</sup> [%]	Country	Potential net energy generation [TWh/annum]	Potential installed capacity [GW]	Average capacity factor [%]	Exclusion <sup>1</sup> [%]
Algeria	24,980.2	7,717.4	36.9%	8.5%	Egypt	10,837.9	3,389.2	36.5%	6.5%
Angola	1,379.2	651.2	24.2%	83.5%	Equatorial Guinea	0.0	0.0	28.8%	100.0%
Benin	163.4	79.4	23.5%	78.5%	Eritrea	528.0	180.6	33.4%	57.8%
Botswana	3,116.7	1,298.8	27.4%	29.7%	! Ethiopia	3,207.6	1,171.1	31.2%	68.8%
Burkina Faso	1,550.2	638.4	27.7%	26.4%	! Gabon	0.3	0.1	24.0%	100.0%
Burundi	2.5	1.2	24.8%	98.7%	Gambia	58.3	27.3	24.4%	18.2%
! Cameroon	277.1	114.1	27.7%	92.3%	! Ghana	149.5	67.8	25.2%	91.1%
Central African Republic	85.0	42.3	22.9%	97.8%	! Guinea	13.9	6.6	23.9%	99.1%
Chad	11,954.3	3,607.4	37.8%	25.5%	Guinea Bissau	5.4	2.7	22.4%	97.4%
Democratic Republic of the Congo	196.0	92.4	24.2%	98.8%	! Ivory Coast	97.9	49.0	22.8%	95.2%
! Djibouti	187.9	58.5	36.7%	27.5%	Kenya	2,918.2	1,073.5	31.0%	44.9%
Lesotho	16.7	7.4	25.9%	92.4%	Senegal	1,270.1	492.1	29.4%	21.2%
Liberia	0.1	~0.0	25.1%	~100.0%	Sierra Leone	0.5	0.2	25.1%	99.9%
Libya	19,180.4	5,855.4	37.4%	0.7%	Somalia	5,052.0	1,625.7	35.5%	2.9%
! Madagascar	1,920.0	704.4	31.1%	64.5%	Somaliland	1,513.3	504.5	34.2%	13.2%
! Malawi	322.6	128.2	28.7%	67.2%	South Africa	6,970.3	2,712.4	29.3%	31.3%
! Mali	12,426.1	4,047.9	35.0%	9.7%	South Sudan	801.6	356.6	25.6%	82.2%
Mauritania	14,548.3	4,229.4	39.2%	0.9%	Sudan	20,950.4	6,508.4	36.7%	7.0%
Morocco	2,074.4	719.3	32.9%	49.2%	Swaziland	53.5	23.0	26.5%	57.8%
! Mozambique	1,569.9	681.1	26.3%	72.9%	! Togo	62.9	30.6	23.5%	83.1%
! Namibia	4,399.5	1,842.3	27.2%	30.2%	Tunisia	1,596.6	512.3	35.6%	8.1%
Niger	11,897.3	3,846.7	35.3%	7.5%	! Uganda	44.2	20.4	24.7%	97.4%
! Nigeria	3,165.6	1,261.1	28.6%	56.5%	! United Republic of Tanzania	1,564.8	620.4	28.8%	80.1%
Republic of Congo	6.0	2.8	24.0%	99.7%	! Zambia	2,020.5	930.0	24.8%	61.2%
Rwanda	~0.0	~0.0	21.0%	~100.0%	! Zimbabwe	1,073.6	468.7	26.1%	62.2%
Sao Tome and Principe	~0.0	~0.0	28.2%	99.9%					

# Technical potential: Only locations with wind > 7.5 m/s

Rank	Country	P50 [TWh/annum]	Capacity [GW]	Average CF [%]
1	Algeria	20,876.5	6,191.1	38.5%
2	Libya	16,909.7	5,079.1	38.0%
3	Sudan	16,129.8	4,627.9	39.8%
4	Mauritania	13,741.4	3,955.1	39.6%
5	Chad	9,618.9	2,646.8	41.5%
6	Mali	9,103.3	2,758.4	37.6%
7	Egypt	7,913.3	2,319.1	38.9%
8	Niger	7,751.7	2,347.8	37.7%
9	Somalia	3,197.0	946.2	38.5%
10	South Africa	1,279.7	404.2	36.1%
11	Ethiopia	1,203.8	375.2	36.6%
12	Tunisia	1,058.5	314.7	38.4%
13	Morocco	992.4	289.8	39.1%
14	Somaliland	949.4	291.9	37.1%
15	Kenya	862.1	242.6	40.5%
16	Madagascar	706.7	210.0	38.4%
17	United Republic of Tanzania	484.3	152.0	36.3%
18	Namibia	410.0	124.1	37.7%
19	Eritrea	276.8	79.4	39.8%
20	Nigeria	239.7	77.5	35.3%
21	Botswana	183.5	59.0	35.5%
22	Djibouti	134.0	37.4	40.9%
23	Zambia	98.1	31.9	35.1%
24	Malawi	88.4	28.2	35.8%
25	Mozambique	70.2	22.2	36.0%
26	Zimbabwe	34.9	11.7	34.0%
27	South Sudan	27.4	8.8	35.5%
28	Cameroon	12.5	4.1	34.8%
29	Senegal	8.7	2.9	34.8%
30	Ghana	8.7	2.7	36.3%

Not  
Surprising

Total potential for all  
locations > 7.5 m/s:  
= 34,700 GW  
= 118,700 GWh/year

Slightly  
surprising

Very  
surprising!



# Technical potential: Only locations with wind > 8.5 m/s

Rank	Country	P50 [TWh/annum]	Capacity [GW]	CF [%]
1	Sudan	11,705.8	3,294.4	40.5%
2	Mauritania	11,515.5	3,307.1	39.7%
3	Algeria	8,591.8	2,602.2	37.7%
4	Chad	7,470.8	1,994.7	42.7%
5	Libya	5,373.6	1,659.9	36.9%
6	Egypt	4,021.2	1,164.4	39.4%
7	Mali	3,654.0	1,173.6	35.5%
8	Niger	3,174.1	940.8	38.5%
9	Somalia	1,652.3	477.1	39.5%
10	Kenya	533.2	139.6	43.6%
11	Morocco	519.1	143.0	41.4%
12	Tunisia	503.0	150.8	38.1%
13	Ethiopia	355.2	107.4	37.7%
14	Somaliland	324.7	97.4	38.1%
15	Madagascar	320.3	91.2	40.0%
16	South Africa	246.9	75.1	37.5%
17	United Republic of Tanzania	184.7	55.9	37.7%
18	Eritrea	179.3	49.5	41.3%
19	Namibia	139.1	38.3	41.4%
20	Djibouti	97.0	26.0	42.5%
21	Malawi	21.3	6.8	35.7%
22	Nigeria	9.4	2.9	36.9%
23	Zambia	7.7	2.5	35.3%
24	Mozambique	7.2	2.2	37.4%
25	South Sudan	3.5	1.1	37.5%
26	Botswana	1.9	0.6	33.4%
27	Zimbabwe	1.9	0.6	36.0%
28	Democratic Republic of the Congo	0.6	0.2	35.6%
29	Ghana	0.6	0.2	36.3%
30	Cameroon	0.6	0.2	36.9%

Total potential for  
high-wind only

= 16,600 GW  
= 64,700 TWh/year



# Observations

## Turns out that Africa has a great wind resource!

- Looking at all locations, total wind potential = 180,000 TWh/yr = 250x current continental demand
- Two-thirds is in locations with wind > 7.5 m/s
- One-third is in locations with wind > 8.5 m/s, yielding very high productivity

## Wind resource is surprisingly distributed:

- 27 countries on their own could satisfy the entire continental electricity demand (17 of these have average capacity factors over 30%)
- Many countries with no projects have great potential:
  - Algeria: 24,980 TWh (34% in high wind)
  - Tanzania: 1,564 TWh potential (12% in high wind)
  - Malawi: 322 TWh potential (7% in high wind)
  - Namibia: 4,399 TWh (3% in high wind)
  - Nigeria, Cameroon, Mozambique, Ivory Coast ...



# Conclusions

## Why Wind for Africa?

1. Tremendous untapped wind potential
2. Competitively-priced power
3. Complementarity with solar
4. Minimal disruption of land use
5. Opportunity for community benefit sharing

## Key pieces of the puzzle:

1. Follow environmental & social good practice
2. Need strong policies and clear targets
3. Transmission and energy access
4. Smart integration of variable power
5. Transparent tenders with a focus on bankability  
(building on Scaling Solar success?)



### Local Benefit Sharing in Large-Scale Wind and Solar Projects

Discussion Paper  
June 2019

